CLAIMS

What is claimed is:

1. An acoustic logging apparatus comprising:

(a) a drill collar conveyed on a drilling tubular in a borehole within a formation, said drill collar having a cutoff frequency for a collar mode wave therein; and

(b) a transmitter on the collar producing a signal at a frequency below said cutoff frequency, said signal comprising primarily of a formation mode.

2. The logging apparatus of claim 1 wherein the cutoff frequency is determined at least in part by a thickness of the drill collar.

3. The logging apparatus of claim 1 wherein the drill collar further comprises a plurality of segments.

4. The logging apparatus of claim 1 wherein said collar mode is a quadrupole mode and said transmitter is a quadrupole transmitter and said signal comprises a quadrupole signal having an azimuthal variation substantially given by $\cos 2\theta$, where θ is an azimuthal.

5. The logging apparatus of claim 1 further comprising at least one signal detector on the drill collar for detecting said signal, said at least one signal detector spaced apart from the transmitter in an axial direction of the collar.

6. The logging apparatus of claim 5 wherein the at least one signal detector further comprises a plurality of detector elements disposed circumferentially about the collar

7. The logging apparatus of claim 6 wherein the transmitter further comprises a plurality of transmitter elements

8. The logging apparatus of claim 7 wherein the plurality of transmitter elements is the same as the plurality of detector elements

9. The logging apparatus of claim 5 wherein said at least one signal detector further comprises a plurality of axially spaced-apart signal detectors.

10. The logging apparatus of claim 8 wherein said detector elements are azimuthally aligned with elements of said transmitter.

11. The logging apparatus of claim 7 wherein said detector elements are azimuthally aligned with a junction between adjacent elements of said transmitter.

12. The logging apparatus of claim 4 wherein said quadrupole transmitter further comprises 2N pairs of diametrically opposed transmitter elements disposed circumferentially around said collar, where N is an integer.

13. The logging apparatus of claim 12 wherein N is equal to one.

14. The logging apparatus of claim 4 wherein said quadrupole transmitter comprises two dipole transmitters.

15. The logging apparatus of claim 4 wherein said transmitter further comprises a plurality of elements including a material selected from: (i) a piezoelectric material, (ii) an electrostrictive material; and, (iii) a magnetostrictive material.

16. The logging apparatus of claim 4 wherein said transmitter further comprises a device selected from (i) a bender bar, (ii) an electromechanical device, and, (iii) a porthole.

17. The logging apparatus of claim 6 wherein said detector elements further comprise a material selected from: (i) a piezoelectric material, (ii) an electrostrictive material; and, (iii) a magnetostrictive material.

18. The logging apparatus of claim 6 wherein said detector elements further comprise a device selected from (i) a bender bar, and, (ii) an electromechanical device.

19. The apparatus of claim 5 wherein the at least one signal detector is spaced between the transmitter and a drillbit conveyed on the drill collar.

20. The apparatus of claim 5 wherein the at least on signal detector further comprises at least one additional signal detector spaced axially apart from the at least one signal detector.

21. The apparatus of claim 1 wherein said formation has a shear velocity greater than a compressional velocity of a fluid in the borehole and said signal further comprises a first quadrupole mode and a second quadrupole mode, said transmitter operating at a frequency above an Airy phase associated with the first quadrupole mode.

22. An acoustic logging apparatus comprising:

(a) a drill collar conveyed on a drilling tubular in a borehole within a formation, said drill collar having a cutoff frequency for a collar mode wave therein;

(b) a transmitter on the collar producing a signal, said signal comprising a formation mode and a collar mode;

(c) at least one signal detector on the drill collar for detecting said signal, said at least one signal detector spaced apart from the transmitter in an axial direction of the collar and receiving signals including the formation mode and the collar mode; and

(d) a processor including a filter for low-pass filtering of a component of the received signals having a frequency below the cutoff frequency.

23. The logging apparatus of claim 22 wherein said collar mode is a quadrupole mode and said transmitter is a quadrupole transmitter.

24. The logging apparatus of claim 22 wherein the at least one signal detector further comprises a plurality of detector elements disposed circumferentially about the collar.

25. The logging apparatus of claim 24 wherein the transmitter further comprises a plurality of transmitter elements.

26. The logging apparatus of claim 23 wherein said quadrupole transmitter further comprises at least 2N pairs of diametrically opposed transmitter elements disposed circumferentially around said collar, where N is an integer

27. The logging apparatus of claim 25 wherein said transmitter elements further comprise a material selected from: (i) a piezoelectric material, (ii) an electrostrictive material; and, (iii) a magnetostrictive material.

28. The logging apparatus of claim 25 wherein said transmitter elements further comprise a device selected from (i) a bender bar, (ii) an electromechanical device, and, (iii) a portnole

29. The logging apparatus of claim 22 wherein the at least one detector further comprises a plurality of detector elements comprising a material selected from: (i) a piezoelectric material, (ii) an electrostrictive material; and, (iii) a magnetostrictive material.

30. The logging apparatus of claim 22 wherein said formation has a shear velocity greater than a compressional velocity of a fluid in the borehole and said signal further comprises a first quadrupole mode and a second quadrupole mode, and said processor further comprises a filter for high pass filtering said signal above an Airy phase associated with the first quadrupole mode.

31. A shear wave logging apparatus comprising:

(a) a drilling collar conveyed on a drilling tubular in a borehole within a formation, said drilling collar having a cutoff frequency for a collar mode wave therein;

(b) a quadrupole transmitter on the collar producing a signal at a frequency below said cutoff frequency, said signal comprising primarily of a formation mode having an azimuthal variation substantially having a $\cos 2\theta$ variation, wherein θ is an azimuthal angle;

(c) at least one detector spaced axially apart from the quadrupole transmitter for detecting said signal; and

(d) a processor for processing the detected signal and determining therefrom a shear velocity of the formation.

32. A shear wave logging apparatus comprising:

(a) a drilling collar conveyed on a drilling tubular in a borehole within a formation, said drilling collar having a cutoff frequency for a collar mode wave therein;

(b) a quadrupole transmitter on the collar producing a signal, said signal comprising a formation mode and a collar mode;

(c) at least one detector spaced axially apart from the quadrupole transmitter for detecting said signal;

(d) a processor for processing the detected signal using a filter for low pass filtering components of the signal below said cutoff frequency and determining therefrom a shear velocity of the formation.

33. An apparatus for obtaining information about a parameter of interest of a subsurface formation during drilling of a borehole therein comprising:

(a) a drill collar conveyed on a drilling tubular in the borehole, said drilling collar having a cutoff frequency for a collar mode wave therein;

(b) a quadrupole transmitter on the collar producing an acoustic signal at a frequency below said cutoff frequency, said signal comprising primarily of a formation mode indicative of a shear velocity of the formation;

(c) a drillbit operatively coupled to said drilling collar, said drillbit adapted to drill the borehole upon rotation of the drilling collar;

(d) at least one detector disposed between the transmitter and the drillbit, said

at least one detector receiving said signal; and

(e) processor for processing said detected signal and determining therefrom the parameter of interest.

34. A method for obtaining information about a parameter of interest of a subsurface formation comprising:

(a) conveying a drill collar on a drilling tubular into a borehole within the formation, said drill collar having a thickness and an associated cutoff frequency for a collar mode wave therein;

(b) using a transmitter on the collar for producing a signal at a frequency below said cutoff frequency, said signal indicative of the parameter of interest;

(c) using at least one signal detector on the drill collar for detecting said signal; and

(d) processing said signal to obtain the parameter of interest.

35. The method of claim 34 further comprising operating a drillbit coupled to the drill collar for further drilling of the borehole.

36. The method of claim 34 further comprising tripping the drill collar and performing steps (b) and (c) during said tripping.

37. The method of claim 34 wherein said transmitter is a quadrupole transmitter

comprising two pairs of diametrically opposed transmitter elements and producing said signal further comprises:

activating each element of each pair to produce a signal having an azimuthal dependence of cos 2θ, where θ is the azimuthal angle.

38. The method of claim 34 wherein said further comprises two dipole transmitters.

39. The method of claim 34 wherein the at least one signal detector further comprises detector elements disposed circumferentially on the collar.

40. The method of claim 39 wherein said at least one signal detector further comprises a plurality of axially spaced-apart signal detectors.

41. The method of claim 34 wherein the transmitter comprises a quadrupole transmitter and the at least one signal detector comprises two detector elements, the method further comprising operating the transmitter at a first time with one polarization and at a second time with a second polarization.

42. The method of claim 40 wherein processing said signal further comprises using said plurality of axially spaced-apart detectors for beam steering.

43. The method of claim 34 wherein said formation has a shear velocity greater than a compressional velocity of a fluid in the borehole and said signal further comprises

a first quadrupole mode and a second quadrupole mode, said transmitter producing a signal above an Airy phase associated with the first quadrupole mode.

44. A method of using an acoustic logging apparatus on drilling collar conveyed on a drilling tubular in a borehole within a formation, the method comprising:

(a) using a transmitter on the logging apparatus for producing a quadrupole signal comprising a formation mode and a tool mode;

(b) using at least one signal detector on the drilling collar spaced apart axially from the transmitter for detecting said signal; and

(d) using a processor for low-pass filtering a component of the detected signal having a frequency below a cutoff frequency of the tool mode in the drill collar.

45. The method of claim 44 wherein said transmitter is comprises two pairs of diametrically opposed transmitter elements and producing said signal further comprises:

activating said elements to produce a signal having a cos 2 θ azimuthal variation.

46. The method of claim 44 wherein said transmitter further comprises two dipoles.

47. The method of claim 44 wherein the at least one signal detector further comprises detector elements disposed circumferentially on the collar.

48. The method of claim 44 wherein said at least one signal detector further comprises a plurality of axially spaced-apart signal detectors.

49. The method of claim 44 wherein the at least one transmitter comprises a quadrupole transmitter and the at least one signal detector comprises two detector elements, the method further comprising operating the transmitter at a first time with one polarization and at a second time with a second polarization.

50. The method of claim 48 wherein processing said signal further comprises using said plurality of axially spaced-apart detectors for beam steering

51. The method of claim 44 wherein said formation has a shear velocity greater than a compressional velocity of a fluid in the borehole and said signal further comprises a first quadrupole mode and a second quadrupole mode, the method further comprising using said processor for high pass filtering said signal above an Airy phase associated with the first quadrupole mode.

52. A method of determining a parameter of interest of an earth formation using a shear wave logging apparatus on a drilling collar, the method comprising:

(a) conveying the drilling collar on a drilling tubular in a borehole within the formation, said drilling collar having a cutoff frequency for a collar mode wave therein;

(b) using a quadrupole transmitter on the collar for producing a signal at a frequency below said cutoff frequency, said signal comprising primarily of a formation mode;

(c) using at least one detector spaced axially apart from the quadrupole transmitter on the drilling collar for detecting said signal; and

(d) using a processor for processing the detected signal and determining therefrom a shear velocity of the formation.

53. A method of determining a parameter of interest of an earth formation using a shear wave logging apparatus on a drilling collar, the method comprising:

(a) using a quadrupole transmitter on the collar for producing a signal, said signal comprising a formation mode and a tool mode;

(c) using at least one detector spaced axially apart from the quadrupole transmitter for detecting said signal;

(d) using a processor for processing the detected signal using a filter for attenuating components of the signal above said cutoff frequency and determining therefrom a shear velocity of the formation.

54. A method of obtaining information about a parameter of interest of a subsurface formation during drilling of a borehole therein comprising:

(a) conveying a drilling collar conveyed on a drilling tubular into the borehole, said drilling collar having a cutoff frequency for a collar mode wave therein;

(b) using a quadrupole transmitter on the collar producing an acoustic signal at a frequency below said cutoff frequency, said signal comprising primarily of a formation mode indicative of a shear velocity of the formation;

(c) using a drillbit operatively coupled to said drilling collar for drilling said borehole;

(d) using at least one detector disposed between the transmitter and the drillbit for receiving said signal; and

(e) processor for processing said received signal and determining therefrom the parameter of interest.